BISCUIT OVENS

There are many different oven designs and progress is constantly being made. It is not possible to give an exhaustive summary of how all types of oven work or are controlled because of the engineering detail that would be required. Most biscuits are baked in a tunnel oven in a continuous process but there are some cases where a static oven is used and trays of dough pieces are put into the oven and removed after a suitable interval. Static ovens will not be considered here even though they are the type usually employed in test bakeries.

Typically biscuits are baked in long tunnel ovens. The ovens are made up of a number of independently heated and controlled zones. The shortest ovens may have only one zone but longer ovens have two or many more zones. A typical configuration consists of three or four zones. The provision of zones allows different temperatures, heat applications and extraction conditions to be provided as the dough pieces are baked into biscuits.

The production rate of an oven is defined by its length and the baking time needed to bake a product to the desired structure, colour and moisture content.

It is not easy to measure heat compared with the ease with which temperature is measured. In the early ovens a lining of refractory bricks permitted considerable storage of heat which helped to reduce changes in oven air temperatures when passage of product was intermittent. However, it takes some time to heat these bricks when the oven is started and a long time to cool them at shut down. Thus, there is considerable inertia if the product requires a higher or lower heat input. The important feature, however, is that a considerable amount of heat can be transferred to the product by radiation and some feel that this is the best method of baking.

To overcome many of the inconveniences of the brick lined ovens there has been a general move towards lightweight oven structures turbulence is used and this introduces the need to achieve uniform and controllable air movement within the oven.

Provision is always made to vary the ratio of heat that can be supplied to the top and bottom of the product.

Biscuit ovens are available to suit the type of fuel to be burnt (gases and oils, of varying qualities, or electricity) and to dissipate this heat either directly or indirectly into the oven chamber. Fuels for ovens are all becoming relatively more expensive and although the cost of fuel is a small proportion of the total production cost of biscuits, there is nevertheless a growing concern to improve oven efficiency and to use less fuel.

Extraction of the oven atmosphere is via ducts and flue pipes that take the gases out through the roof of the factory. Extraction may be natural or aided with fans. The latter is to be preferred as natural extraction is much affected by the wind speeds and temperatures outside the building. The amount of extraction is controlled by a slide valve in the flue pipe, usually before the extraction fan.

Ovens of all types tend to have a large number of control points offering a bewildering range of possibilities. In many cases problems are increased because the controls are only crudely calibrated and are located along the length of the oven.

The product is taken through the oven on a continuous band (rarely the oven band is a chain that takes trays). Through the oven the band is supported on metal skids or rollers spaced sufficiently close to one another to prevent appreciable sagging of the band between them.

After passing through the oven the band returns under the oven usually outside the hot chamber. In this position it can be cleaned with wire or fabric rotating brushes.

In some cases provision is made for treating the band or its surface immediately before the dough pieces are panned onto it. These include preheaters, oiling sprays or rollers and flour dusters.

5.2 Direct fired ovens

In direct fired ovens the heaters are inside the baking chamber and are arranged above and below the baking band. The products of combustion (mostly carbon dioxide and water) come into contact with the dough pieces so only clean gas (or electric) heaters can be used in direct fired ovens. There can be an appreciable buildup of 'humidity' from combustion of the gas. As there is a significant amount of radiant heat from each burner/heater there are usually a large number of individual burners to provide a more or less even heat application as the biscuits pass through the zone. More heat is required at the front of the oven than at the back. Because the oven band and the dough pieces have to be heated quickly, there are usually more burners in the first zone than later ones. The heat is controlled either by varying the amount of gas being supplied to each burner or by turning off selected burners. The gas and air mixture supplied to each burner is made by pressurising either the gas or the air and blowing it through a venturi tube to make a suitable gas and air mixture.

There are usually control systems on all or a number of the burners to allow variable disposition of heat across the oven band. Adjustment of these is usually the engineer's, not the operator's, task.

The control system also incorporates safety systems so that the burners cannot be lit while there is a mixture of gas and air in the baking chamber and a complete shut down of the fuel system occurs if the oven band stops. Control of the oven temperature is via thermocouples sited within the baking chamber which modify the amount of gas passed to each burner.

Sometimes there is also provision for increasing the turbulence of the oven atmosphere to improve the heat transfer. This must be limited otherwise the flames on the burners may be extinguished. In order to achieve the benefits of good turbulence and thus good heat transfer by convection, some direct fired ovens have a single large burner per oven zone and the hot gases circulate through the oven chamber and back to the burner. These resemble, in design, indirect fired ovens, described below, in which the products of combustion do not pass into the baking chamber.

Direct fired ovens are the most powerful in terms of heat transfer. There may also be preheaters under the front of the oven to heat the oven band before dough deposition.

Figure 2 shows a typical design of a direct gas fired oven.

Electric ovens are a special case of direct fired ovens. Heater elements are arranged like the gas burners, above and below the band and either each is controllable or groups are controlled. Electric ovens are easy to start and stop and are the easiest type of oven to control. The extraction requirement is much less, with economy considerations, since there are no products of combustion but the

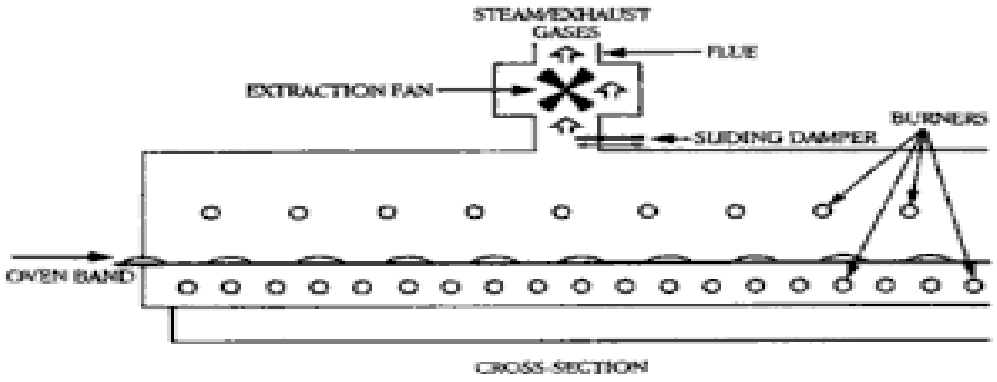

Fig. 2 A typical design of a direct gas fired oven.

oven 'humidity' is derived only from moisture lost by the product being baked.

Sadly, electricity is an expensive fuel in most countries so electric ovens are not universally common. However other more creative methods of using electricity for baking are being developed. These include special high powered radiant heaters for controlling surface colouring precisely and microwave and dielectric heating systems that do not colour but allow improved moisture removal and heat the centre parts of the dough piece. The use of electricity is mentioned again in Section 5.4.

5.3 Indirect fired ovens

Indirect fired ovens are so called because the products of combustion do not enter the baking chamber. There has to be a heat exchanger system to heat the oven atmosphere. Indirect fired ovens usually have one large burner per zone and this may be fuelled either by oil or gas. Either the hot gases from the burner are circulated through ducts which are in the baking chamber (and therefore radiate heat) or air from the baking chamber is circulated over a large heat exchanger near to the burner. Whichever is the system, dampers are provided to control and divert the passage of the hot gases to various parts of the oven chamber or up flues to the atmosphere. Flues must be provided for the products of combustion and for ventilating the baking chamber. The flue from the burner is not normally capable of restriction.

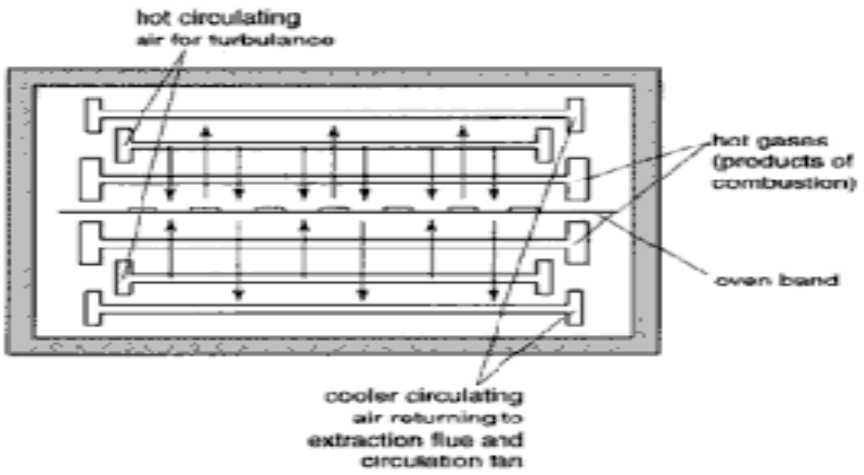

Fig. 3 One zone of an indirect fire oven.

Indirect fired ovens offer the design engineer flexibility in providing more or less radiant heating from hot tubes, and more or less convected heating by air circulation. The methods of heating can be different in successive zones of a tunnel oven.

Figure 3 shows a schematic design of one zone of an indirect fire oven.

5.4 Hybrid ovens

The number of independently controlled zones and the length of these zones should ideally be designed to suit the product being baked. It is possible therefore to have ovens composed of direct and indirectly fired sections. These are called hybrid ovens.

There is not enough power available in indirect fired ovens to bake most laminated crackers but the strong convection heating systems of indirect fired ovens suits moisture removal in the later sections of all ovens. Hybrid ovens therefore normally have one or two direct fired zones followed by indirectly fired zones.

The selective use of electric power may also be a feature of hybrid ovens with microwave power used along with another type of power. The use of dielectric power is usually in a unit after the oven, as will be explained in Section 7.

5.5 Types of oven bands

Oven bands are generally available in 800 mm, 1000 mm and 1200 mm widths, although other sizes can also be obtained. There are various types of band which offer varying degrees of openness, weight and usage life. Sheet steel bands may be 1.2 mm or 1.3 mm in thickness and weigh about 9 kg per square metre. Perforated steel bands, with holes of varying diameter, are available and these give the strength and durability of steel bands but with improved ventilation of the product base. They are expensive. There are various wire bands ranging from the light square mesh types (such as 5 × 5, etc. describing the number of weaves per inch and weighing about 3.5 kg per square metre), to the looped wires which offer greater product support, improved durability and great flexibility at the terminal drums. Heavy flattened chevron type woven wire bands offer the extremes in band weight at around 19 kg per square metre. These bands are particularly favoured by producers in the USA but it will be appreciated that considerable power is needed to heat the band in the first part of the oven.

Provision is made to track the band to prevent it running over the edges of the terminal drums and thus damaging the structure of the oven or the band itself. To change a band is a large task and bands are expensive because of their considerable length.

5.6 Preparation and care of oven bands

Before a new oven band can be used for baking, it is necessary to prepare it. This involves conditioning and cleaning. The cleaning is principally a process of removing mineral oil and dirt, and in the case of wire bands this can be simply done by rubbing the band, after heating to about 150°C, with clean cloths. Steel bands (including perforated steel bands) require more attention in order to create a clean shiny surface which will not allow the product to stick while baking. It is customary to heat the band to about 150°C and to rub a fat into it, heat it through the oven and then to rub this off again at the oven exit with clean cloths.

A rough surface due to scratches, metal pitting or a buildup of carbon from charred fats or dough particles tends to cause product sticking. The conditions which cause the product to stick are not always obvious but a thin film of vegetable oil usually prevents the keying of sticky substances such as syrup or milk products which